Effect of Intracanal Cryotherapy on Reducing Root Surface Temperature

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Abstract

Introduction: The positive effect of cryotherapy has been widely described in medicine. The aim of the present study was to validate a new methodology to reduce and maintain external root surface temperature for at least 4 minutes. **Methods:** Twenty extracted single-rooted teeth were instrumented to size 35/.06 and subjected to 2 different irrigation interventions with a repeated-measures design using 5% sodium hypochlorite first (control) and 2.5°C cold saline solution later (experimental). In both, 20 mL of the irrigant solution was delivered for a total time of 5 minutes with a microcannula attached to the EndoVac system (Kerr Endo, Orange County, CA) inserted to the working length. The initial and lowest temperatures were recorded in the apical 4 mm with a digital thermometer for both irrigants. Data were analyzed with the repeated measure analysis of variance (Greenhouse-Geisser correction) and Bonferroni post hoc tests. Differences in maintaining a −10°C temperature reduction over 4 minutes were assessed with the Fisher exact test. **Results:** Although significant differences were found between the initial and lowest temperatures in both the control and experimental irrigation procedures ($P < .001$), the experimental intervention reduced it almost 10 times that of the control. When maintaining a −10°C temperature reduction over 4 minutes, the teeth in the experimental group also sustained significantly better results ($P = 3.047 \times 10^{-10}$). **Conclusions:** Using cold saline solution as the final irrigant reduced the external root surface temperature more than 10°C and maintained it for 4 minutes, which may be enough to produce a local anti-inflammatory effect in the periradicular tissues. *(J Endod 2015;41:1884–1887)*

Key Words

Cryotherapy, EndoVac, negative pressure irrigation, temperature reduction

The term *cryotherapy* is derived from the Greek word cryos, meaning "cold." In physiotherapy, it means lowering or decreasing the temperature of tissues for therapeutic purposes. In reality, cryotherapy does not imply implementing cold but rather extracting heat (1, 2). The magnitude of the temperature change and the biophysical alterations in the tissues depend on the difference between the temperature of the object and the application of cold or heat, exposure time, thermal conductivity of the tissues, and type of agent used to apply the heat or cold. The use of this type of therapy in human tissues causes changes in the host's local temperature (3, 4).

The 3 basic physiological tissue responses after the application of either heat or cold are an increase or decrease in local blood flow, stimulation or inhibition of neural receptors in the skin and subcutaneous tissues, and an increase or decrease in metabolic activity (2). Physiological and clinical evidence suggest that cold therapy, in different forms, may reduce musculoskeletal pain, muscular spasm, connective tissue distension, nerve conductivity time, hemorrhage, and inflammation (1, 2).

Bleakley reported that cold therapy seemed to be efficient in limiting inflammation and reducing pain in the short-term (5). According to Van't Hoff's law, cryotherapy causes vasoconstriction and slows down cellular metabolism by limiting biochemical reactions. Vasoconstriction produces antiedema, and a reduction in pain is achieved after temperature reduction because of blocking of the nerve endings that cold produces (6). The intensity of the vasoconstriction effect reaches the highest value at a temperature of 15°C (6). In fact, some studies have shown that the highest temperature in the skin that produces therapeutic effects (anesthesia, analgesia, or muscle relaxation that allows post-treatment movement of painful areas) is 16°C (5). A temperature decrease from 30°C to 17°C was achieved after only 15 minutes of cold therapy (1, 2). Lowering the body temperature also decreases peripheral nerve conduction, and when it reaches less than 15°C, nerve conductivity is deactivated completely.

Ice application reduces tissue temperature, blood flow, pain, and cell metabolism, which minimizes the degree of tissue damage and the lesion caused by secondary hypoxia (5). An important reduction in local enzyme activity and profound local vasoconstriction occur after cold application. The analgesic effect is produced by a combination of a decreased release of chemical mediators of pain and a slower propagation of neural pain signals. Also, metabolism is lowered more than 50%, which allows better oxygen diffusion into the injured tissues (5).

Despite the generalized use of cryotherapy in medicine, there is little scientific basis for the methods used in efficient application. A systematic understanding of factors such as the time necessary to cool down an area, the time during which this area remains cold enough after removal of the cooling agent, and the amount of cooling

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that extends beyond the area in contact with the cooling agent have so far received scant attention in the scientific literature (1, 2).

In dentistry, cryotherapy has been used after intraoral surgical procedures such as periodontal surgery, extractions, and implant placement (7), but there are no studies on the effect of intracanal cryotherapy to lower the external root temperature in order to reduce inflammation of the periapical tissues, resulting in a certain degree of pain relief. One way to apply cryotherapy to the inflamed periradicular tissues is by intracanal irrigation with a cold substance after flaring the root canal system. This has been proven to be an easier task when using a negative pressure irrigation system such as the EndoVac system (Kerr Endo, Orange County, CA) (8). The microcannula (MICRO) of the system can be placed to the full working length (WL) and be used to aspirate the irrigant with a continuous flow (8, 9).

This article suggests a new methodology for intracanal cryotherapy that should be histologically and clinically validated in future studies. The specific objective of the present study was to determine whether the external temperature of the apical 4 mm of root canals could be reduced after continuous irrigation with cold (2.5°C) saline solution and maintained for at least 4 minutes.

Materials and Methods

Uniradicular roots of 20 freshly extracted human teeth were selected for this study. Those roots with incomplete apexes, decay, fractures, fissures, abnormal anatomy, or previous endodontic treatment were discarded. All roots were standardized to 15 mm, immersed in 5% sodium hypochlorite (NaOCl) for 30 minutes, and immersed in distilled water to prevent dehydration until needed for the experiment.

Access was gained with a size 4 round bur (Brasseler USA, Savannah, GA) using an air turbine handpiece (Brasseler USA) under copious water cooling. To establish the WL, a #10 K-file (Kerr Endo) was inserted into the root canal until it was visible through the foramen, and 0.5 mm was subtracted from that distance. All canals were instrumented to a #20 K-file to the WL, and the TF Adaptive system (Kerr Endo) was used to further flare the root canal to the WL up to an ML 2 (35/.06) instrument. Two milliliters of 5% NaOCl was used to irrigate the root canal after each instrument. A final rinse with 17% EDTA (REDTA Roth International, Chicago, IL) was used to irrigate all root canals for 1 minute and then dried with sterile paper points.

After cleaning and shaping, the teeth were mounted on an acrylic device designed to hold them in place and were further fixed with clay. The teeth were isolated with a rubber dam and Block-Out Resin (Ultradent Products, South Jordan, UT). Type K thermocouples (model TP-01 (Thomas Edison Co, Wengzhou, China), RoHs compliant [temperature range, −50°C to 1350°C], connected to a digital thermometer [A-Plus Type K RoHs; Thomas Edison Company, Wengzhou, China]), were attached to the apical 4 mm of the root surface. A flexible Young's rubber dam frame was used to allow visibility of the root and thermocouples while irrigating (Fig. 1)

The 20 teeth were subjected to 2 different irrigation interventions: a control irrigation using NaOCl 5% at room temperature (first) and the experimental cold irrigation using 2.5°C saline 5 minutes later. Both initial and lowest temperatures for each intervention were recorded for the apical 4 mm using the thermocouples connected to the digital thermometer described previously.

The control irrigation, performed first, consisted of 20 mL NaOCl 5% delivered at the WL with the EndoVac system for 5 minutes. The master delivery tip and a 31-mm MICRO were used during this procedure. Both the syringe and the NaOCl solution were used at room temperature. Irrigation time was controlled with a chronometer. The initial temperature (time point 1) and the lowest temperature reached during the procedure (time point 2) were recorded; if a reduction of −10°C was maintained for at least 4 minutes, this was also recorded.

The experimental irrigation was performed 5 minutes later on the same specimens. The same irrigation procedure was performed, except for the use of a cold irrigant solution (2.5°C cold saline) and cold MICROs. The experimental irrigation consisted of 20 mL 2.5°C cold saline solution delivered at the WL with the EndoVac system for 5 minutes. The master delivery tip and a 31-mm MICRO were used during this procedure. Both the saline solution and the MICRO were kept in a calibrated refrigerator at 2.5°C until used. Irrigation time was controlled with a chronometer. The initial temperature (time point 3) and the lowest temperature reached during the procedure (time point 4) were recorded; if a reduction of −10°C was maintained for at least 4 minutes, this was also recorded.

Five roots were used as positive controls and another 5 as negative controls. Positive controls were kept in the freezer for 24 hours. Then, the external temperature was measured. In negative controls, the temperature of the root surface was measured at room temperature.

After confirming the assumption of normal distribution of the recorded temperatures, a repeated measures analysis of variance (ANOVA) was used to detect any overall difference among the 4 intrasubject measurements. A Greenhouse-Geisser correction was applied to the repeated-measure ANOVA because the data violated the assumption of sphericity. A Bonferroni post hoc test was used for pairwise comparisons and to interpret further main effects of interaction of the intrasubject. Pre-post measurements were made of the irrigation procedures when repeated measures ANOVA showed significant differences. The Fisher exact test was also used to compare the number of samples that were maintained at a −10°C temperature reduction for 4 minutes.

Results

The average temperature of positive controls was −30.8°C, whereas negative controls showed an average temperature of 23.2°C. In the experimental teeth, the temperature started to descend within seconds and decreased 10°C after an average of 30 seconds.

The lowest temperatures recorded were 5.2°C and 20.4°C in the experimental and control irrigation interventions, respectively.

As shown in Table 1, the mean temperature differed significantly among the 4 different time points ($P = 9.14 \times 10^{-25}$). Post hoc tests using Bonferroni correction revealed significant differences between pre-post control intervention temperatures (time points 1 and 2, $P = 3.03 \times 10^{-6}$) and pre-post experimental intervention temperatures (time points 3 and 4, $P = 9.27 \times 10^{-17}$). However, although the control intervention slightly reduced the initial temperature in the specimen (mean difference = 1.56; 95% confidence interval, 0.941–2.179), the experimental intervention (mean difference = 14.33; 95% confidence interval, 12.94–15.72) reduced it almost 10 times as much as the control.

Moreover, when the maintenance of a −10°C temperature reduction for 4 minutes was assessed, the teeth in the experimental group also exhibited significantly better results ($P = 3.047 \times 10^{-10}$). No temperature reduction was found in any of the teeth in the control group, whereas only 1 of 20 in the experimental group did not show a 10°C reduction over the 5 minutes.

Discussion

This *in vitro*, within-subject design or repeated measures study was intended to readily detect differences across levels of the independent variable (temperature) and to compare changes in the root surface temperature of extracted teeth after a novel method of irrigation with